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ENGINEERING PRODUCTION

By Dr. N.A. DUDLEY,
Lucas Professor of Engineering Production,
University of Birmingham.

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D. 10. Engineering Production

Dr. N.A. Dudley,
Lucas Professor of Engineering Production,
University of Birmingham.

1. Industrial advance is usually assessed in terms of technical development and of the rate of application of new and improved techniques; in terms of, for example, the adoption of automatic self-correcting devices for controlling manufacturing processes, or of high-speed automatic data-processing equipment and the introduction of new materials and larger and faster machine tools. From time to time, comparative studies are made of the increasing ratio of horse-power to man-power employed in production, or of the numbers of electronic computers installed in different industries. Studies are also made of the time-lag between the emergence of new techniques or processes from the research laboratory, and their general acceptance and routine application in the factory. Agencies are set up by government departments and by research and other associations to disseminate information about these innovations, and to encourage and accelerate their adoption when the time-lag appears excessive.

2. While such developments increase the potentialities for increased production, however, it by no means follows that their adoption automatically or inevitably leads to an increased total volume of production from the factories in which they are installed, nor that what is produced is produced more economically. This is as true of the more highly developed industries as it is of the less highly developed, for, whatever the level of technical development, there is always scope for more effective Engineering Production.

3. Engineering Production is concerned primarily with the planning, organising and control of manufacturing industry. It is a study embracing all aspects of production - technical, human, economic- and has been developed to meet the need for more efficient production. Its emergence as a unified science and technology-

now recognised at the highest academic levels - is mainly due to the considerable research effort which has been directed, in recent years, to the discovery and understanding of the nature, characteristics and interaction of the various agents of production, and of the principles upon which the planning, co-ordination and control of industrial production should be based.

4. Much attention is being directed to an understanding of industrial skills, to the characteristic behaviour of machine tool and other processes and particularly to man-machine control systems. The attainment of technical perfection of the tools of production and of their competent operation, however, is but one stage in efficient and economic engineering production. If the output of individual machines and processes and of workers were infinitely adjustable, and if the desired volume and quality of output at any moment were those which could be produced at minimum cost per unit, production planning would present no serious problem. In fact, because of the different output rates of production processes, there is a tendency for work to pile up between certain machines and for certain other machines and workers to be kept waiting. Superimposed on the inherent differences in capacity and quality of output of new machines are the effects of age and use and misuse. Machines have to be serviced and they have to be maintained. Their capital cost and running cost varies, as does the cost of raw materials and of labour and the demand for the finished products.

5. Preparation of the simplest production plan involves (or, rather, should involve) consideration of many variables, and research is being undertaken so that - in determining optimum production strategy - scientific evaluation of the situation may supplant trial and error and supplement experience. The investigations, aimed at promoting more efficient planning of production, are of two kinds: those concerned with advancing knowledge of the characteristics of the available tools or agents of production and of their interaction, and those concerned with developing techniques by the use of which inefficiencies may be illuminated and the most effective means of attaining specific production objectives identified.

6. The need - even in highly developed industries - for research aimed at securing a better understanding of the tools of production arises mainly from the preoccupation of most machine designers with the technicalities of the individual piece of equipment. While much is known about the immediate performance of new machine tools and other equipment at the time of their construction and installation, little is known, as yet, about the rate of wear of machines and the effect of wear on tolerances, on the quality and quantity of output and, not least, on the patience of the operator. This knowledge is of paramount interest and importance to the production engineer. In much the same way, little is known about the physical and mental capacity of workers, and of the limitations imposed by age, health, working conditions and so on, although some progress has been made in dimensioning variations in performance of semi-skilled workers on repetitive tasks, both when they are free to work at their own speed and when they are paced by a conveyor belt, machine or other workers.

7. While there has been a tendency to concentrate on developing and refining "productivity improvement" techniques to perfect the more advanced and highly developed industries, considerable improvements in productivity may be effected by the use of less sophisticated techniques in small scale and under developed industries. The techniques - of universal application-range from elementary method study and process planning to ergonomics studies in which physiological and psychological factors are weighed against technical requirements and economic restrictions, and to the systematic analysis of complete manufacturing systems by use of the more rigorous tools of operational research.

8. The primary work analysis and methods improvement techniques - capable of more or less routine application - could undoubtedly be of immense benefit to the less developed areas, for, while the relatively high cost of labour and of labour disputes in highly developed and highly organised industries gives impetus to the drive towards automatic production, the relative abundance of labour in under developed countries indicates that increased productivity should be sought mainly by way of more effective utilisation of labour and of such capital resources as are available, or as can appropriately be made available.

9. There are countless examples of rapid improvements of production efficiency - of marked reductions in production time and cost - that have been achieved by the application of relatively simple techniques of work analysis and measurement and a critical and searching examination of methods of working, of procedures and of layout of factory departments. Such improvements, resulting from the elimination of unnecessary or unnecessarily fatiguing or time-consuming activities and, as far as possible, of idle time, have seldom involved any appreciable capital expenditure but they have always resulted from an active collaboration of management and workers. Such collaboration is seldom difficult to establish once it is made clear that more effective work does not necessarily mean more arduous work and assurances are given that all concerned will benefit from the increased productivity.

10. In the field of production planning and control, many of the refined techniques of analysis and measurement that are now being developed and applied in the most advanced industrial countries, are also immediately applicable in the under developed countries, though perhaps not always in precisely the same way, for there is little point in employing these more powerful tools where relatively simple and routine techniques can make a major impact. Although the less developed areas have many obvious disadvantages in some respects, they have decided advantages in others. For example, an industrial company in the United Kingdom, or in the United States, might employ linear programming to determine where depots or warehouses should be located , or should have been located, and the optimum size of such depots under given circumstances. In less developed countries, major decisions on location and size of facilities, affecting not merely one particular company, but entire industries, and indeed the whole community, could be readily made, and with far fewer restrictions or constraints than are commonly encountered in the more highly developed industries. Other associated mathematical and statistically-based techniques developed in recent years under the label operational research or operations research, can enable major and long-term policy decisions to be determined on a scientific, or at any rate, quantitative basis, and in accordance with an overall industrial or community plan. Problems relating to allocation of resources, product targets and inventory levels, problems concerned with determining optimum operating conditions, the conditions under which production cost may be minimised, or profits maximised, may be solved by these means.

11. The sponsoring, by the governments of under-developed countries and by various international agencies, of young scientists , mathematicians and engineers on postgraduate courses of study in operational research in the United Kingdom and in the U.S.A. and elsewhere, is recognition of the service that the operational research approach can render in the quest for more efficient engineering production.

12. In recent years, research into the organisation of batch production industries - that is, the type of production likely to be typical in less developed countries within the forseeable future - has revealed many characteristic features and problems of which industrial managers should be aware when seeking to improve existing industries or when planning and developing new ones. For many years, much effort has been given to developing methods of determining economic batch sizes, in the assessment of which the capital tied up in work-in-progress and the cost of delays, (involved when products or components must wait for the rest of the batch to be processed,) are weighed against the time and cost of setting up machines and changing over tools and other equipment to suit a succession of batches of different components. The more recent researches, however, have revealed that these delays, inherent in batch production, are a mere fraction of the total delays associated with and commonly found in this type of manufacture.

13. Much time is lost in, for example, transporting materials from the raw material stores to work stations, between work stations and on to the despatch department, simply because of the nature of the organisation commonly found in batch production industry. In so far as it is a technical matter - a question of layout of factories and arrangement of processes - the problems and the principles underlying their solutions are universal. Bearing in mind, however, that many of the problems or causes of delay - and certainly the most critical - are of a psychological or sociological nature, it would appear that similar researches must be carried out in the conditions actually obtaining within less developed areas. An additional and compelling reason for repeating such studies is, of course, the impact on productive efficiency of climate, of local traditions and customs and of terms of employment prevailing in those areas.

14. It may be found in those areas - as in the case of more highly developed industry - that work is not transferred as speedily as it might be from one section to another merely because, in batch production factories, manufacturing departments or sections tend to become self- contained, concerned exclusively with a particular production process. Often there is no clear definition of duties and responsibilities for those concerned with the actual movement of materials from one section to another. It may be that the head of a section is preoccupied only with securing an adequate supply of material for his group of workers, and has no incentive to transfer finished work speedily to the next section. It may be found here, too, that a factory manager allows finished work to accumulate simply because his director is agreeably impressed by the sight of a large stack of finished work. It may be that here, also, the psychological effect of the amount of work presented to a worker on the worker's performance is of greater significance than any economic justification or determinant of batch size.

15. At the level of the manufacturing process itself, it is clear - particularly in the light of what has already been said - that local conditions must determine the desirable degree of mechanisation. In general, this will fall short of completely automatic production. In some of the largest and most efficient mass production factories, large numbers of workers are employed on assembly and other operations, (even though the work could be readily mechanised) merely because it is more economical to the companies for workers to be so employed. This must surely be the case, also, in the less developed areas, where there is a more plentiful supply of labour which can be trained for repetitive work of this kind. What is of paramount importance, however, is that individual production processes should be carefully method-studied with due regard, not merely to mechanical efficiency, but also to ease and simplicity of operation. Since the type of machine tools and other basic manufacturing equipment likely to be increasingly in demand in the less developed areas is the standard and general purpose variety, and since such machines are usually of fairly simple design and construction, their production can, with advantage, be encouraged in those areas. It would be unfortunate, however, if imported designs were slavishly reproduced and without due regard to the data that are to hand, and should be made available, on the design and location of manual controls.

16. In highly developed industry, lip service is paid to scientific worker selection, but under conditions of near full employment, it is impracticable, if not impossible, to carry vocational selection as far as one would wish. In the less developed areas, however, there appears to be unlimited scope for careful and systematic guidance, selection and initiation of workers as well as for specialised operative training as now practised in the most advanced industries.

17. Trends towards automatic production in the most advanced large scale industries are sometimes hindered by the fact that, for certain kinds of work, including some so-called semi-skilled work, the skills and special abilities of the operator seem indispensable and irreplaceable; A number of researches are being pursued in the United Kingdom, with Government support, to determine the nature of certain of those industrial skills, and in particular those used in the control of various kinds of machine. One example of this - in the mass production of motor cars - is the sensitive drilling of small diameter holes in certain components, another - in a tube mill - is the manual slitting of drawn tubes. The immediate objective of such researches is to identify and dimension the signals from which the operator derives the information on which he acts, and to determine the precise nature of the response which he makes.

18. The outcome of such research might be, either to enable the manual controls of machines to be improved so that they may be more easily, more speedily or more accurately manipulated or to enable the workers' skill to be simulated in the design of automatic controls. It is perhaps looking some way into the future to foresee the need for similar researches in the less developed areas. Being aware, however, of how great sometimes are differences in performance of workers within a particular industry or factory, there would be an obvious danger in attempting to translate the findings of such researches from a more highly to a less highly developed community, and thus, sooner or later, fundamental and applied research of this kind will need to be pursued in the less developed areas.

19. On the other hand, comparative studies of production planning, organising and control activities in different industries within a given community, reveal many common characteristics. For example, the advantages of the division of labour, with its resultant specialisation and increased efficiency of performance, have long been acknowledged and noted as a key factor in industrial development, so that the manufacture of many products now involves a long series of individual and discrete production processes of comparatively short duration. As long ago as Adam Smith, the contribution of this division of labour to increased productivity was being recognised, and quite recently experimenters have been concerned with the probable and conjectured physiological and psychological effects of such monotonous and repetitive work. Not until the current studies of batch production, however, has it been observed that the range of times to process a batch, increases directly with every additional process to be performed. This is as true of the manufacture of boots and shoes as it is of the manufacture of machine tools. There is much to be learned on such matters in both the more developed and the less developed areas. What the more advanced students of engineering production have to offer, are research techniques which will enable a better understanding of the characteristics of different types of production to be achieved, and thus enable production to be more effectively planned and controlled.

20. One of the most striking causes of increased productivity has been the growing acceptance of the principles of specialization and standardization. Small scale jobbing and batch production factories have been enabled to share some of the advantages of large scale production by standardising product components or component features wherever possible. For example, the manufacturer of an extensive range of small internal combustion engines - with orders ranging from two or three to twenty of any particular type - has found it possible to satisfy the needs of all types of engine with only two sizes of piston. To be effective, efforts of this kind demand not only determination and patience, but the ability to plan and introduce an investigation procedure in which the work of designers, development, production and methods engineers and market research specialists is smoothly integrated.

21. It was a weakness of even the highly industrialised areas not so long ago that the need for a distinct engineering function charged with the effective integration of all aspects of

production was not always recognised. It is still a weakness in some quarters that the nature of this function is conceived too narrowly. High technical efficiency is not always synonymous with high overall productivity. We speak of the increased productivity of a new piece of manufacturing equipment, but what really matters is the impact of this machine on the entire production unit in which it is installed. A technically less advanced machine may be better integrated into the production flow; indeed the term production flow seems to have no real meaning in many otherwise technically advanced companies. In other words, there has been no really systematic attempt to ensure that production does flow smoothly and effectively. The techniques needed are, for the most part, relatively simple. Where they are not - as for example, in certain applications of queueing theory - they do not necessarily involve great capital expenditure. It would seem, therefore, that in the efficient use of such resources as are available the less developed areas could be brought up to the level of, if not surpass, the performance of the many so-called highly developed areas. The rapid development of Engineering Production studies is a measure of its contribution to productive efficiency. (It is but 14 years since Engineering Production was introduced into a British university as a subject for postgraduate study, and the first professor appointed. Within the last 12 months, the first B.Sc. degree course has been approved, and the International Journal of Production Research launched, under the sponsorship of the British Institution of Production Engineers.) There is already conclusive evidence that science and technology of Engineering Production are of universal application.

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